# THE NAVIGATOR

AFRP 50-3, Volume XXXI, Number 1, Spring 1984

# NAV OF NOTE

**COLONEL JOHN B. TARSOLY**

Colonel John B. Tarsoly took command of Mather's 323rd Flying Training Wing on 31 March 1983. The 323 FTW conducts training in navigation and related specialities for the Air Force, Navy and Marine Corps. The wing also trains navigators for selected Free World countries.

Born in Hungary, Colonel Tarsoly attended Salesian High School in New Rochelle, New York. In 1959, he obtained an ROTC commission and a bachelor of science degree in Electrical Engineering from the University of South Carolina. Next he attended communications officer training at Keesler AFB, Mississippi, and then served briefly with the 727th Aircraft Control and Warning Squadron at Myrtle Beach AFB, South Carolina.



"It wasn't easy for me to get into flying training," he recalls. "My ROTC physical revealed that I was nearsighted. Also, I failed the depth perception test. Thus, I was disqualified for both pilot and navigator training. But I was determined to fly. While at Keesler, I talked a flight surgeon into giving me another eye exam and this time I passed the depth perception test. Five months later I was in navigator training."

After earning his navigator wings at James Connally AFB, Texas, Colonel Tarsoly completed navigator-bombardier training at Mather AFB in September 1961. His initial navigator assignment was with the 345th Troop Carrier Squadron at Sewart AFB, Tennessee. In 1962, the entire squadron was transferred to Naha AB, Okinawa, where Colonel Tarsoly flew a variety of resupply, troop deployment, and air drop missions in support of expanding United States operations in Southeast Asia.

From Okinawa, the colonel was reassigned to the 965th Airborne Early Warning and Control Squadron, McClellan AFB, California. Serving initially as a crew navigator, he moved through a variety of wing staff positions including communications officer, wing navigator, and operations staff officer of the 552nd Airborne Early Warning and Control Wing. "To be candid, the routine radar picket missions off the West Coast were somewhat tedious and unchallenging. So I declared myself available for any and all additional duties. Soon I was moving from one responsible wing staff position to the next. In two years, I had the best job of any captain in the wing—project officer for Southeast Asia (SEA) operations of Aerospace Defense Command's only unit committed to the war effort. My only problem then was convincing my boss to release me to fly a tour of duty with our deployed task force. I finally prevailed and flew 50 combat missions before leaving SEA for AFIT."

From January 1968 to June 1969, Colonel Tarsoly studied for a master's degree in Computer Science at Texas A&M. Upon graduation, he volunteered to return to Southeast Asia. He was assigned to the 554th Reconnaissance Squadron, Korat Royal Thai AB, Thailand. There, on his third mission, he was involved in a major aircraft accident and was hospitalized for two months and grounded for an additional five. He served as Headquarters Squadron Commander until he regained flying status, completing his tour in June 1970. Upon return to the states, the colonel attended the Armed Forces Staff College.

Following intermediate service school, Colonel Tarsoly served with the Air Staff as an operations data analyst in the Air Force Command Post for a year and, later, as an air operations staff officer in the Worldwide Military Command and Control Systems Division. He was the Operations Directorate project officer for the development and deployment of the Advanced Airborne Command Post.

From August 1975 to June 1976, Colonel Tarsoly attended the Air War College. In July, he moved to Stuttgart, Germany, where he served as the Iran desk officer in the Security Assistance Division, Headquarters, U.S. European Command. In August 1978, he became Chief of the Command's Middle East/Africa branch. In February 1979, the colonel assumed duties as Assistant Chief of Staff for Plans and Exercises and Senior U.S. Officer, Headquarters Baltic Approaches (NATO), Karup Air Station, Denmark. "I've never had a bad assignment in the Air Force," he states matter-of-factly. "And clearly the jobs in Germany and Denmark were not exceptions. I had the opportunity to travel in the Middle East and Africa and to appreciate the organizational, personnel, equipment and training problems of other nations. In Denmark, I was exposed to the full slate of NATO issues and the consultation process among allied but sovereign nations. Planning large scale multinational joint exercises required diplomatic as well as military skills. My assignments in Europe were exciting and highly rewarding."

Returning to the U.S. in July 1981, Colonel Tarsoly served as commander and professor of Aerospace Studies of the ROTC detachment at Syracuse University, where he was responsible for recruiting, educating, training, and commissioning a new generation of Air Force officers. "To take a civilian student, who is clearly undecided about the future, and mold this young person into an officer and leader motivated to serve the Air Force is not only a challenging but a most gratifying experience," according to the colonel.

"Some distinct parallels exist between my former ROTC mission and my present responsibilities. While the primary Mather mission is to produce the best navigators in the world, we must not lose sight of the fact that one's first commitment is to be the best officer possible. The continuation of the ROTC mission—the building of a firm foundation of good officership—is still one of my major objectives today. To achieve this goal, we must instill in our second lieutenants a sense of duty, mental and physical discipline, a pride in flag and country, and a keen sense of honor. Not surprisingly, one of my first acts as wing commander was to prominently display on base the West Point motto of Duty, Honor, Country."

"The 323 FTW has a tremendous record of accomplishments and enjoys a topnotch reputation in the Air Force. My predecessors have done a great deal to improve the base and 'fine tune' the training program. I intend to maintain the momentum I've inherited. Looking around Mather today, you see a base in motion—people reaching out for higher professional standards, excellence in training, an enhanced quality of life, and personal satisfaction in job performance. The spirit of Mather's people is contagious and it fuels the engines of progress. We are right on track. The young men and women graduating from our courses will continue to be the finest officers, aviators and warriors the Free World can produce."

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Department of the Air Force

# THE NAVIGATOR

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A choice assignment for USAF flyers is selection for duty in an allied air forces exchange program. In this issue we're pleased to offer a USAF/RAF exchange perspective from the first USAF instructor WSO assigned to the Tornado. Our cover painting symbolizes the understanding and goodwill that grow from the shared experience of service with our allies. For more on duty with the Royal Air Force, read "A WSO's Eye View of the RAF" on the following page.



*Distribution: One copy per four navigators.*

# A WSO's Eye View of the RAF

**Captain Darrel R. GREER**
**USAF/RAF Exchange Program**
**RAF Honington, UK**

Though navigators, observers, and bombardiers have crewed in many two-place cockpits since World War I, weapon systems officers (WSOs), fightergators, or fighter-pilot navigators really haven't been around very long—at least not the way we know them today. We're quite a young fraternity. Today's "pitters" in the USAF are indebted to those electronic warfare officers (EWOs) of the sixties who strapped into the pits of F-100Fs and F-105Fs to start a new chapter in tactical aviation. Later came the decision to man the rear seat of F-4s and the right seat of F-111s with navigators and call them WSOs. Vietnam era fightergators were a special breed who worked hard to prove the role of navigators in fighter cockpits.

Since its advent, our fraternity has certainly grown worldwide. It presently includes navigators in the US Navy and US Marine Corps, as well as many of our allied air forces. Our brethren go by many different names. Besides the USAF WSO, EWO, AND RSO (reconnaissance systems officer), the USN has its NFO (naval flight officer) and BN (bombardier-navigator), and the Royal Air Force (RAF) boasts its "fast-jet nav." Nicknames such as Bear, GIB (guy-in-back), pitter, and right-seater are common. Regardless of what we're called, we perform a myriad of duties besides navigation, including copilot, EWO, bombardier, flight engineer, radio operator and more.

From a professional development standpoint, our varied duties prove there is always something new for us to learn, study, and share. Every professional looks for ways to improve personal skills and knowledge, and thereby his profession. We can grow professionally by comparing how we do things with the methods of others.

This opportunity to compare is just one benefit of the USAF Foreign Exchange Program. Exchange officers receive a golden opportunity to examine their host government's operating concepts and actively participate in diverse flying operations. Courtesy of the USAF Foreign Exchange Program, I've enjoyed two memorable years with the RAF as the first USAF instructor WSO assigned to the RAF Tornado. During my first year, I traveled the United Kingdom (UK) participating in various training programs and observing many others. This experience has permitted me to view RAF operations from a WSO's perspective and to note contrasts with the USAF. These contrasts arise from a potpourri of interesting concepts, some philosophical, others more tangible. I'll describe several contrasts to help you appreciate the RAF fast-jet nav experience.

The first significant contrast is the RAF attitude about flying. This is a bit philosophical

RAF Tornado taxis for takeoff.

but, in the RAF, flying is fun and that's the way they want it to be. The RAF keeps its emphasis on flying. Though additional duties exist and must be accomplished, flying is a crew member's first responsibility. This RAF attitude is really an extension of the British public's enthusiasm for aviation—a remarkable enthusiasm rarely seen in other nations. Anyone who's served a tour in the United Kingdom undoubtedly will confirm my view.

So, what is the significance of this enthusiasm? The RAF believes, and so do I, that if an aviator really enjoys flying, he will be more flexible, adaptable, and capable in critical situations. Situational awareness improves since the aviator who enjoys flying is more able to take in data, process it, and convert it to useful information. A high level of situational awareness is critical for an effective combat force. Attitude plays a big part in developing it.



Don't think this implies that the RAF is a "flying club." Nothing could be further from the truth. The organization is every bit as professional as the USAF. British rules and regulations governing flying are almost identical to ours. The RAF develops an aviator who looks forward to flying, fights for every sortie, and works hard when airborne—doing his thing.

In our USAF, especially among WSOs, some believe we've drifted away from that attitude. Some view flying as a square-filler—something good for career progression. A few years ago, *Aerospace Safety* magazine (now *Flying Safety*) published an article espousing the virtues of flying as something which should be fun. The article echoed the British idea that when flyers enjoy their work they perform better and work safer.

Professionals should enjoy their jobs, whether on the ground or in the air. Those who don't should find another profession. To make a job enjoyable means having the right attitude about your work. That attitude must be shared by both the employer and the employee. As an employer, the RAF does indeed encourage the attitude that "flying is fun."

Of course to excel professionally, proper training is required, and RAF fast-jet navigator training is impressive. Unquestionably, RAF training develops airmanship skills and situational awareness second to none. Besides teaching basic navigation skills, fast-jet training provides plenty of intense low-level flying. These sorties produce a navigator who's ready for the rigors of tactical aviation.

During the first phase of basic navigator training at RAF Finningley, students fly 16 high-level sorties in the Dominie (similar to a T-39) and 20 low-level sorties in the Jet Provost (JP—resembling a T-37). Low level means as low as 250 feet above ground level (AGL). If selected as a fast-jet nav candidate, students then fly at least 21 additional Dominie and 15 additional JP sorties stressing low-level radar and visual navigation, formation, crew cooperation, and, most importantly, airmanship. Dominie sorties are flown at 500 feet AGL. By the time a student graduates, he's flown about 85 sorties, of which 45 are in the JP.

After navigation school comes Tactical Weapons Unit (TWU) training in the Hawk at RAF Brawdy or RAF Chivenor. The Hawk is a great little tandem two-seater, ideal for fighter orientation. Rear cockpit visibility is superb and, because the Hawk has only a stopwatch, compass, and airspeed meter as navigation aids, it provides an excellent platform for further skill development. At the TWU, students learn to function as part of a fighter team. Additional studies stress academic range work and tactical scenarios. Most navigators fly 30 to 40 sorties at the TWU before moving to their fighter assignments.

Fighter or fighter-bomber conversion training usually entails 35 to 50 sorties per student depending on aircraft type. Very few of these are flown at medium altitudes. The operational

Capt Darrel Greer (right), the first USAF exchange officer in the RAF Tornado, talks shop with Capt Bob Linnell (pilot).

RAF flyers plan a mission.

conversion units (OCUs) teach aircraft systems and academic weaponry, with emphasis on offensive and defensive tactical employment. The navigator must navigate, operate electronic warfare aids, monitor aircraft performance, maintain a first-rate lookout, control the formation during tactical exercises, and make most of the radio calls (another exercise which develops situational awareness).

A quick tally shows that an RAF fast-jet nav shows up at his first operational squadron with at least 150 sorties to his credit. That's almost twice the number the average USAF WSO boasts when arriving at his first squadron. Any experienced backseater will tell you it's far more important to have the sorties for developing airmanship and situational awareness than merely academic hours.

Both airmanship and situational awareness are hallmarks of the RAF fast-jet squadron navigator. He is expected to plan, fly, and fight. After seeing RAF navigators in action, I have the greatest respect for their abilities and professionalism. The RAF fast-jet navigator's responsibility and performance provide another interesting contrast.

Good flying starts with good planning. RAF navigators have no canned route folders for training on the multitude of low-level routes. New charts are drawn every day for every mission. Though there are some preplanned routes for specific missions, they're the exception not the rule, and navigators must draw their own copy. Developing route and attack plans promotes flight planning skill. Each plan automatically reflects all those considerations studied in tactics manuals.

Good mission planning also requires the right tools. Unlike their USAF counterparts, RAF squadron navigators are encouraged to develop their own templates to expedite the planning process, but they have ready access to a number of quality planning tools. When a novel idea for a flight planning tool surfaces, the device is usually manufactured and made available through supply channels. A sample of such tools appears in Fig 1. The trusty old USAF plotter and dividers are rarely seen in the RAF navigation planning room. With the right tools and skills, flyers can produce a masterpiece chart in a matter of minutes—one that would make even the purist SAC nav proud.

When the plan is complete, they fly it—so long as weather and airspace restrictions permit. If unforeseen elements preclude the primary plan, no problem. RAF navigators have a hip-pocket backup for every situation. They appear to thrive on planning deviations. As highly regarded members of the fighter team, navigators must produce alternative solutions. In fact, you will rarely see an RAF pilot, from a two-seat aircraft, carrying a map. That's the GIB's responsibility. The GIB's judgment commands respect.

Such is also true for multiship situations. Naturally, the lead navigator is responsible for getting the formation to the target, but he also handles most radio transmissions (RT) with controlling agencies along the route. When the formation is attacked by an aggressor aircraft, the first crew member to see the aggressor directs defensive maneuvers. If that flyer happens to be a navigator, fine. And if a formation split is required, the GIB may also direct that, even up to rejoin for route continuation.

Squadron navigators are used so well, they develop uncanny heads-up awareness. Heads are constantly moving—always looking out and projecting ahead. To appreciate the RAF fast-jet nav's situational awareness, consider this example related to me by an F-111 operations officer at RAF Upper Heyford. Last year, on an F-111/Buccaneer squadron exchange in Germany, he gave a Buccaneer navigator a familiarization ride in the F-111. Needless to say, the Buc nav had a bit of trouble with the



RAF flight-planning tools

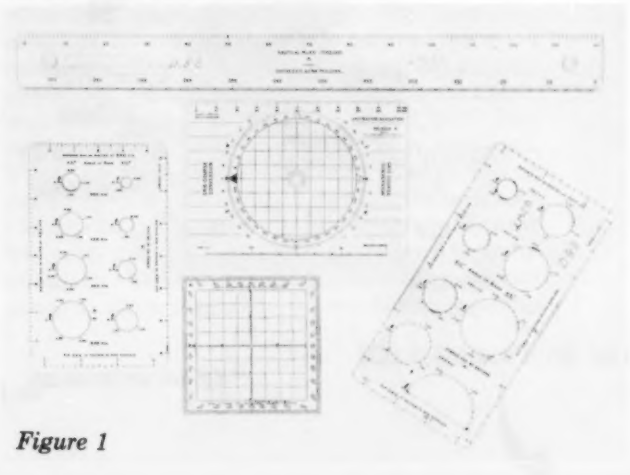
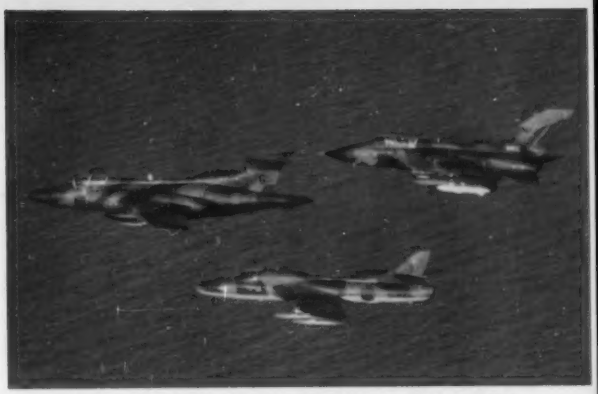


*Figure 1*

switchology on the navigation computer and the radar. Nevertheless, he did extremely well navigating in poor visibility using basic dead reckoning. During tactical formation maneuvers, he even monitored the other F-111 so well that he directed it around a sensitive area on the low-level route. When poor weather caused the formation to abort the low level, the Buc nav very calmly and professionally took over the RT with the controlling agency. Not bad for a guy on his dollar ride!

The contrast in navigator use also extends to training units. Instructor fast-jet navs are in the pit when a student pilot drops his first bomb from a Tornado or Buccaneer. Most instructor pilots at OCUs are not even back seat qualified. Those who are, fly familiarization rides and instrument checks. This is true in basic OCU training and advanced Qualified Weapons Instructor training (equivalent to the USAF's Fighter Weapons Instructor Course).

Map depicts locations of RAF bases employing WSOs, relative to British population centers.



Pictured are the three aircraft operated at RAF Honington: Buccaneer (left), Tornado (right), and Hunter (foreground).

Basically, the RAF approach is that pilots train navigators and navigators train pilots. Buccaneer training is the most extreme example. A student pilot gets one familiarization ride with an IP in the backseat. If he can land the airplane and doesn't go non-current, that's his last Buccaneer ride with an IP. All weapons delivery, low level, and tactics instructional rides are flown by a navigator instructor. The success of this approach is borne out the by the feedback from Red Flag or Maple Flag programs after a Buccaneer visit.

Tornado training is a bit different because of political elements involved with tri-national OCU training at RAF Cottesmore and individual nation weapons training. Suffice it to say, as an instructor on the Tornado Weapons Conversion Unit at RAF Honington, I'm in the pit for a student pilot's first laydown, toss, or dive bombing sortie. I'm there on his first night automatic terrain following radar sortie, on his first heavyweight bomb sortie, and on his first tactical evasion sortie. That's quite a change from the way the USAF uses IWSOs.

In a squadron or OCU, the fast-jet nav flies more than his USAF counterpart. I typically average one sortie per day for most months. That's more than double what I considered a good month in my F-111 days. Most F-4 and F-111 IWSOs in USAF training units are lucky to log over five sorties per month. The RAF considers a high sortie rate as critical for proficiency.

The final contrast between USAF and RAF operations is the UK low flying system. Though California is about 50% larger than Great Britain, at least twice as much tactical airspace is available for day-to-day use in Britain as in California alone. Except for heavily populated areas, such as Greater London, Liverpool, Birmingham, etc., most of the UK is open for low flying, down to 250 feet AGL at 420 knots.

Naturally, low flying is prohibited in many small areas, including the five-mile radii around military airfields. Excluding airways and restricted areas, controlled airspace doesn't begin until FL 245.

For the tactically minded, there is extensive freedom for planning in the low-level environment. A wide variety of simulated targets can be attacked including bridges, dams, railheads, industrial sites, and even airfields. In this relatively small airspace, such freedom is essential to maximize training during poor weather or to enhance missions requiring specific tactical scenarios. It's a boon to training at all levels. Regardless of the phase or type of training, heads-up awareness is essential. On any given sortie, five or six different types of aircraft may operate in the low-level system. If you spot another aircraft, just "waggle your wings" and press on. (Unless he happens to be a designated aggressor attempting to intercept you!)

The advantages of such a system need to be stressed from the WSO perspective. From the day you start flying in the UK, you're heads up. Too many aircraft are down in the weeds with you for your lookout to get complacent. Besides, nothing is more embarrassing than to have the enemy roll in at your six o'clock, ready to fire. Navigation skills must be good to avoid violations of controlled airspace when operating in congested areas. When the situation dictates, deviations from planned routes are allowed for tactical evasion or timing control.

The low-level system has to be highly organized since well over 20 military air bases operate within UK airspace. When you throw in the major and minor civilian airfields, the number of aircraft airborne at any one time can be astronomical. Yet it's a safe system, not because of the "big sky theory," but because of aviator skills. The RAF low-level system is the envy of the other NATO nations.

Considering the RAF attitude toward flying, navigator training, and navigator use, I think you'll agree that the RAF fast-jet nav experience is a terrific learning situation for our USAF WSO fraternity. As I enter my last year in the exchange program, I look forward to continuing my education in the world of RAF WSOry and enjoying some of the best flying anywhere in the world.

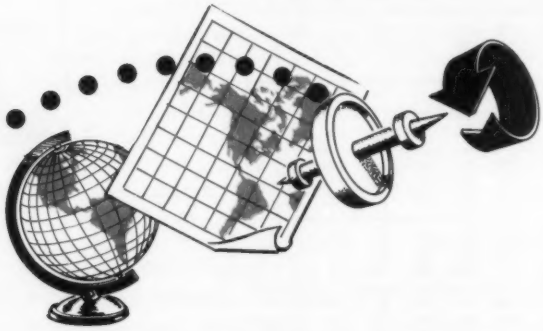
Cheers!

**Capt Greer graduated from the University of West Florida with a degree in physics and was commissioned via OTS. After UNT and EWT, he served in the F-111 at Korat AB, Nellis AFB, and Mt Home AFB. In 1980, he obtained his master's degree in Business Administration. Capt Greer now serves in the USAF/RAF Exchange Program.**



# Nixing Grid Transport Precession

**Major Michael J. SIEVERDING**
**34 TATG/TTX**
**Little Rock AFB, AR**



Grid procedures have been part of aerial navigation since the advent of accurate gyro compasses during World War II. Long range aircraft with transpolar missions prompted the use of heading systems referenced to something other than magnetic north. In the high latitudes, magnetic compasses produce serious navigational problems because of converging meridians, rapidly changing magnetic variation, and wavering magnetic fields. The USAF Grid system was developed to solve these problems. Fliers navigate by reference to a square grid drawn over a chart's converging meridians and curving latitudes. With Grid, aircraft can fly over the poles without significant or frequent heading changes. Today's military and commercial aircraft either manually reference their heading

gyros to Grid or have automatic Grid capability built into their avionics.

Referencing gyros to Grid may have solved many problems, but the procedure also produced some. Free-wheeling gyros drift from the direction of their original orientation. Much of this gyro drift, called precession, is caused by the earth's rotation. Gyro compasses were designed to include a latitude input to compensate for this earth rate precession. A second form of precession, called real precession, is caused by faults within the gyro itself. Frequent celestial observations and gyro updates can minimize the seriousness of this problem. With today's modern gyros, real precession error is negligible.

A third kind of precession is produced by the Grid overlay itself. A flat, two-dimensional chart cannot accurately display the surface of our spherical earth. With flat navigational charts, some distortion always exists. Straight lines drawn on the chart are not straight lines over the earth. A gyro will apparently precess as it is transported along this straight line on the chart. Such grid transport precession (GTP) becomes greater as chart distortion increases. On conventional subpolar flight charts, GTP is greatest when flying true east/west and is negligible when flying true north/south. GTP can make the navigator believe that the gyro is malfunctioning. In turn, this perception causes inaccurate precession rates to be carried on the in-flight log during major course changes. GTP, which can exceed four degrees per hour, contributes to centerline deviation. Yet, no convenient method exists to compensate for it. Transverse Mercator polar projection charts do not require GTP compensation because they use a non-square Grid lattice which is accommodated in flight by the Transverse Mercator Convergence Graph. This graph is in AFM 51-40, Figure 2-29 (in the 15 March 1983 manual) or Figure 3-22 (earlier editions). Subpolar Lambert Conformal flight charts, however, do not compensate for GTP.

The old AFM 51-40, Volume III, capably defined GTP and included a series of complex correction graphs. The current AFM 51-40 includes only a cursory definition. In Advanced Navigator Training academics, GTP is introduced, but dismissed from serious discussion. Operationally, some SAC navigators approximate a GTP correction when extreme accuracy is required during their annual Navigation and Bombing Competition. Still, some USAF navigators are unaware of the existence or impact of grid transport precession error.

I offer the simplified checklist inserts (Figure 1) which enable you to correct for GTP error by presetting a false latitude into the gyro compass. The correction tables were generated through the following equations:



**EQUATION 1**

$$GTP = \frac{\sin \text{True Course} \times \text{Groundspeed}}{\cos \text{Latitude} \times 60} \times (\sin \text{Latitude} - CF)$$

where CF = chart convergence factor

**This equation was extracted from AFM 51-40, Volume III and can be inferred from the current manual.**

## GTP CORRECTION TABLES

LATITUDE VALUE TO COMPENSATE FOR EARTH RATE AND GRID TRANSPORT PRECESSIONS

| | CHART CONVERGENCE FACTOR = .63049 | | | | | | | | CHART CONVERGENCE FACTOR = .31137 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TC ▶ | 090 | 120 | 150 | 180 | 210 | 240 | 270 | GS ▼ | 090 | 120 | 150 | 180 | 210 | 240 | 270 | TC ◀ |
| 25° | 21 | 21 | 23 | 25 | 27 | 29 | 29 | 250 | 01 | 01 | 03 | 05 | 07 | 09 | 08 | 05° |
| | 20 | 21 | 22 | 25 | 28 | 30 | 30 | 300 | 01 | 01 | 03 | 05 | 07 | 09 | 09 | |
| | 19 | 20 | 22 | 25 | 28 | 30 | 31 | 350 | 00 | 00 | 02 | 05 | 08 | 10 | 10 | |
| 30° | 27 | 27 | 28 | 30 | 32 | 33 | 33 | 250 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 10° |
| | 26 | 27 | 28 | 30 | 32 | 33 | 34 | 300 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | |
| | 26 | 26 | 28 | 30 | 32 | 34 | 35 | 350 | 06 | 07 | 08 | 10 | 12 | 13 | 14 | |
| 35° | 33 | 33 | 34 | 35 | 36 | 37 | 37 | 250 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 15° |
| | 33 | 33 | 34 | 35 | 36 | 37 | 37 | 300 | 14 | 14 | 14 | 15 | 16 | 16 | 16 | |
| | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 350 | 14 | 14 | 14 | 15 | 16 | 16 | 16 | |
| ▲ LATITUDE 40° | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 250 | 21 | 20 | 20 | 20 | 20 | 20 | 19 | 20° LATITUDE ▼ |
| | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 300 | 21 | 21 | 20 | 20 | 20 | 19 | 19 | |
| | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 350 | 21 | 21 | 20 | 20 | 20 | 19 | 19 | |
| 45° | 47 | 47 | 46 | 45 | 44 | 43 | 43 | 250 | 27 | 27 | 26 | 25 | 24 | 23 | 23 | 25° |
| | 47 | 47 | 46 | 45 | 44 | 43 | 43 | 300 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | |
| | 48 | 47 | 46 | 45 | 44 | 43 | 43 | 350 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | |
| ▼ 50° | 55 | 54 | 52 | 50 | 48 | 46 | 46 | 250 | 34 | 34 | 32 | 30 | 28 | 26 | 26 | 30° |
| | 56 | 55 | 53 | 50 | 47 | 46 | 45 | 300 | 35 | 34 | 32 | 30 | 28 | 26 | 25 | |
| | 57 | 56 | 53 | 50 | 47 | 45 | 44 | 350 | 36 | 35 | 33 | 30 | 27 | 25 | 24 | |
| 55° | 64 | 63 | 59 | 55 | 51 | 48 | 48 | 250 | 42 | 41 | 39 | 35 | 31 | 29 | 28 | 35° |
| | 66 | 65 | 60 | 55 | 50 | 47 | 46 | 300 | 43 | 42 | 39 | 35 | 31 | 29 | 28 | |
| | 69 | 67 | 61 | 55 | 50 | 46 | 45 | 350 | 45 | 43 | 40 | 35 | 30 | 28 | 27 | |
| 60° | 85 | 78 | 69 | 60 | 53 | 49 | 47 | 250 | 50 | 48 | 45 | 40 | 36 | 32 | 31 | 40° |
| | 90 | 90 | 71 | 60 | 52 | 47 | 45 | 300 | 52 | 50 | 46 | 40 | 35 | 31 | 30 | |
| | 90 | 90 | 73 | 60 | 51 | 45 | 43 | 350 | 55 | 52 | 47 | 40 | 34 | 30 | 29 | |

*Figure 1*

**EQUATION 2**

**Earth Rate Precession (ERP) = sin Latitude X 15.041**

**The constant, 15.041, is the sum of the number of degrees the earth rotates around its axis per hour (15°) and the fraction of a degree the earth passes through during its orbit around the Sun per hour (.041+°). This equation has several reference sources.**

**EQUATION 3**

**False Latitude = inv sign ( (GTP + ERP)/15.041)**

**This equation yields a false latitude up to 90°.**

Each correction table is for a different subpolar chart convergence factor. Convergence factors are listed in the margin of all flight charts incorporating the USAF Grid overlay. Entering arguments for the tables are latitude, true course, and groundspeed. The tables yield a false latitude correction that compensates for GTP error. Corrections can be employed on an hourly basis or after major heading changes. The correction tables were designed to suit C-130 mission profiles but they can be easily modified for other aircraft or missions.

Compensating for GTP will keep an aircraft closer to center line, decrease error in celestially measured precession, improve the accuracy of precession rates carried around turn points, and help navigators identify gyros that are truly out of limits. Obviously, using GTP tables in flight adds one more task to an already busy workload, but the tables could, at least, be consulted during preflight to determine if GTP might be an issue.

The author welcomes any comments regarding grid transport precession—in flight experience and mission impact. A basic language computer program is available to aid correction table construction for high performance aircraft. Please address correspondence to THE NAVIGATOR.

**A 1969 graduate of St Cloud State University, Minnesota, Maj Sieverding was commissioned via OTS. After UNT, he was assigned to Clark AB. Next came assignments to RC-130A photo mapping, the WC-130 at Keesler AFB, and instructor duty at Mather AFB. Maj Sieverding now is a C-130E Simulator Certification Team member.**



**Captain Steve D. DOHERTY**
**7 BMW/DOC**
**Carswell AFB, TX**

# Confessions of a Tanker Navigator

As navigation systems become more sophisticated, so does the job of operating and monitoring them. Today, navigators are called upon to perform their jobs with integrated computer-generated information. The information may or may not be correct. When computer-generated information is incorrect, will you recognize it? More importantly, will your navigational skills save you? How you cope may depend on how well you are prepared.

The setting is Pease AFB, New Hampshire. My crew and I were deploying, single-tanker, on a Coronet East routing to RAF Mildenhall, the United Kingdom. The mission would be a routine deployment, without an air refueling en route. During planning, I was especially alert to the need for precision navigation to avoid an ADIZ violation. I was a second lieutenant on my very first deployment.

We reported to the Tanker Task Force briefing room at 0400 local for our weather and deployment briefing. Weather was perfect for our route. After the briefing, we collected the weather

summary sheets and computer flight plans and reported to our aircraft.

Preflight proceeded smoothly with no unusual events. After reviewing the aircraft 781, I noticed the inoperative Doppler we landed with the previous day had been repaired. Maintenance personnel installed a new Doppler receiver/transmitter unit. Also, a palletized inertial navigation system (PINS) was added. My confidence soared. What could possibly go wrong?

At 0700 local, Abbott 59 started its take-off roll. At the same time, I noticed that the PINS position had already drifted over two miles since initial alignment in the chocks. This was excessive and it alerted me to keep a watchful eye on PINS data. At our departure point, the PINS position was seven miles in error. Having been previously cautioned never to update the PINS, I didn't. I felt somewhat helpless and feared the worst. My fears soon turned into reality. One hundred miles past our coast-out point I took a TACAN fix. The PINS was now over 50 miles off and totally unreliable. I was back to basics—a sun LOP, pressure line of position (PLOP), and Doppler drift and groundspeed.

One hour and ten minutes after takeoff I finally resolved my first independent position. For some reason my sun line and PLOP plotted 20 miles from my DR. I attributed the sun line error to bad shooting technique and scolded the airman boom operator who did my celestial shooting on the KC-135. I rationalized that the PLOP was unreliable anyway. I did not trust the pressure by temperature method of obtaining a PLOP.



My second and third positions only increased my frustration. The sun and pressure LOPs were now 40 and 50 miles from my DR positions, respectively. Only then did I notice that my PLOPs were plotting left, inferring left drift. My Doppler was indicating right drift. This was very strange indeed. I immediately began cross-checking my earlier computations. All were correct.

My anxiety level soon peaked and gave way to verbal abuse of my chart, plotter, and dividers. I knew there had to be an error somewhere, but where? The pilot, seeing my anxiety, quickly became anxious himself. It was then that he asked to see the mission folder and the forgotten copies of the computer flight plan. As I tossed the pilot's copy forward my eyes froze on my copy and the forecast winds and drift. "Positive two," I said aloud, "that's left drift." I had been using negative two, which was still indicating on my Doppler readout. Feldercarb! Now what do I do?

As quickly as I could, I calculated the worst possible situation: bad Doppler, correct computer flight plan winds. If the Doppler was producing incorrect information—the one in sixty rule...I remembered...450 knots—900 miles divided by 60 equals 15 degrees of longitude...times four, the number of degrees of drift error...equals 60 miles. Sixty miles! Could I be sixty miles left of course? "Pilot, Nav," I yelled over the interphone, "contact MacDill airways and get a PIREP with winds for our 0900 position report coordinates." Minutes later the pilot called back, "Winds 180/025, Nav." That confirmed the left drift. As I adjusted my DR position, I wondered how I was going to coax the pilot to turn 45 degrees from flight planned heading to steer back to course. Better yet, how was I going to convince him that I was right?

I spoke calmly and with the confidence of a seasoned navigator, I was later told. "Pilot, Nav. I have reason to believe the Doppler has been giving erroneous drift information for the past two hours. I calculate our position to be 60 miles north of course. Please turn right 45 degrees to heading 140. We should be back on course in 20 minutes." I crossed my fingers for good luck, but I was not prepared for his reply, "Roger, Nav, turning right to 140 degrees." However, as his eyes made contact with mine, his message was loud and clear. I had better be correct. If I was wrong—well, maybe that's why the navigator carries the gun. Right then I couldn't decide if it was for self-defense or self-elimination. No time to worry now though.

With the first crisis past, I determined that I had time for three positions prior to ADIZ penetration. On these three positions, sun and pressure LOPs all fell within five miles of my DR positions. I was either awfully lucky or as lost as an acorn in a rain forest. The remaining minutes were my worst. When the TACAN finally locked on, I heard a sigh of relief from both pilots. I plotted the TACAN fix—eight miles north of course, abeam my DR. Thinking about how far I could have been off course, I broke out in a cold sweat.

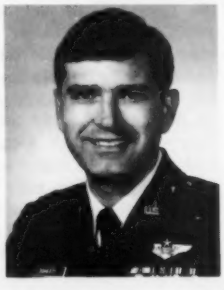
Some very valuable lessons can be learned from this near-disasterous mission. Foremost is the importance of communication and coordination. Mission success and crew safety depend on effective communication and crew coordination. I erred by not communicating with the pilots. Cross-checking forecast winds with in-flight winds should be a required checklist item for pilots and navigators. As a result of my oversight,

the computer flight plans laid idle in the mission folder, forgotten. I could have saved myself a lot of grief had I employed a cross-check after level-off. If only—an afterthought that came much too late.

The second lesson is the need to develop a good system of equipment cross-checks. Blind reliance on your navigational equipment can lead to trouble and, if you're not careful, can produce an error from which you can't recover. I should have caught the Doppler error during coast-out. My inexperience and attention diverted to a failing PINS kept me from this cross-check. In fact, I cannot truthfully say that I would have made the cross-check without these problems. Today, I couldn't forget it if I tried.

As a navigator you must be prepared to use every navigation aid at your disposal, even a computer flight plan. During climb-out or coast-out, use everything and I mean EVERYTHING—TACAN, INS, computer flight plan, and PIREPs from other aircraft. Make sure that your equipment works prior to coasting out of TACAN range. If an error exists, resolve it before it's too late to recover. Remember, when you accepted your navigator wings you accepted an obligation to be the expert in your area of flying and to recognize problems with equipment you routinely use. I believe it's called professionalism. Whatever you choose to call it, it begins with careful planning and systematic regimentation of your flying habits. Plan and fly every training mission as carefully as you would a deployment mission, or better, a check ride. Get into the habit of routinely cross-checking your systems for accuracy. Then, when it comes to the real test, you'll be prepared.

Epilogue: The day we landed at RAF Mildenhall, my pilot cornered me after our in-processing briefing and said, "By the way, Nav, the Doppler shop just called. The Doppler that was replaced at Pease AFB was wired in backwards. Your drift was 180 degrees out." Then he continued, "Say, did I ever tell you about the time I was up against three MiGs when I flew F-4s in Nam?" Pilots like to have the last word.



**A graduate of Southwest Texas State University, Capt Doherty completed UNT in 1974. After CCTS at Castle AFB, he was assigned to Minot AFB in the KC-135. In 1978, he was reassigned to Mather AFB, where he also obtained a Master of Science degree in 1981. Capt Doherty now serves at Carswell AFB.**

# Tracking Down a New Course

**Lieutenant Colonel James M. CONNER**
**3552 USAFRS**
**Wright-Patterson AFB, OH**

To an operational navigator, making decisions and choosing directions are not new endeavors. For field grade navigators, these two tasks take new meaning with career progression.

As rated officers, navigators readily identify with the role of the flying squadron commander and the managerial opportunities that particular job offers. However, the job of Air Force recruiting squadron commander is another exciting opportunity. It offers a broad spectrum of responsibility similar to that of a base commander.

The job of recruiting squadron commander is one of the most challenging managerial opportunities available to the field grade navigator. To accomplish the recruiting mission, squadron commanders employ a large team of highly-trained and very enthusiastic noncommissioned officers—the recruiters. Program management and recruiting support are accomplished by the commander's staff of company grade officers and enlisted personnel. Most squadron support positions are only one-deep. This situation provides the commander with

**LTC Conner (second from left) receives the top USAF recruiting squadron award for the 3552nd. Others pictured from left: Brig Gen Harpe, Chief Cooper, and Gen Ryan.**

some challenging management decisions. The average recruiting squadron includes about 20 positions for headquarters staff and senior NCO supervisors, and 70 field recruiters between the ranks of E-4 and E-6.

A recruiting squadron headquarters is often some distance from a major military installation. But whether a military base tenant or housed in a commercial office, the headquarters is always staffed to be a self-sufficient, independent organization. Recruiting squadrons cut their own TDY orders, manage their own supply accounts and process their own personnel actions.



The Recruiting Service chain-of-command is concise. Senior NCOs supervise an average of eight recruiters per flight. Squadrons usually are comprised of five or six flights with six to eight squadrons per group. Five group commanders report directly to the commander of the Recruiting Service.

There are 35 recruiting squadrons scattered across the country. The 3501st Group, in Massachusetts, includes offices in Europe; and the 3561st Squadron, in Seattle, recruits in Hawaii and the Far East. Two squadrons in the United States are collocated with their group headquarters. Most squadron commanders communicate with their group commanders by occasional phone calls and quarterly meetings.

Making or exceeding the recruiting "goal" is the responsibility of each squadron commander. The Recruiting Service is very similar to the sales department of commercial corporations, with competition permeating all levels of the organization. Our mission is putting people in the blue suit. Squadrons are challenged to enlist their annual shares of Air Force needs, based upon the demographics of their predetermined, clearly-defined territory called a zone.

Geographically, recruiting zones of the different service branches overlap. Air Force squadron commanders are members of Interservice Recruiting Committees, made up of recruiting commanders from the Army, Navy, and Marines. The working relationships established through these committees provide excellent insight into personnel plans and programs of the sister services.

Recruiting programs are generally divided into two areas—enlisted and officer. The enlisted program is split into two sub-programs. The nonprior service program constitutes the bulk (numbers wise) of a squadron's goal. This program requires the greatest number of recruiters and resources. The prior service program recruits individuals who have separated from the armed forces and are needed to fill critical skills as experienced middle managers.

Under the general heading of officer programs, both line and medical officers are recruited. Requirements for line officers, over the past couple of years, have been primarily in the rated and engineering fields. In the medical field, nurses and a relatively small number of physician specialties are sought. Although the Recruiting Service only needed 52 physicians for fiscal year 1983, attaining the goal was difficult. To meet Air Force needs, the physician program focused on recruiting a limited number of medical specialties, specifically neurologists and orthopedic surgeons.

Within this highly competitive and close-knit organization, the primary mission is to meet Air Force manpower requirements with the best people. Aside from goals and quotas, the recruiting challenge also embraces integrity, quality, and professionalism. As a recruiting squadron commander, a navigator is tasked to build the future. The quality of high school and college graduates, doctors, and four-year college nursing graduates entering the Air Force today determines the success of our service tomorrow.

You, as a navigator and possibly a recruiting squadron commander, can help steer that course. To be selected for a career broadening assignment as a recruiting squadron commander, annotate your Air Force Form 90. For more information, call Headquarters, Recruiting Service, AV 487-3511.

**Commissioned through ROTC at the University of Nebraska in 1965, Lt Col Conner holds master's degrees from Nebraska and Ball State Universities. After UNT, he was assigned to the RF-4C, serving a SEA tour and four years at RAF Alconbury. Next came assignment to Mather AFB before duty at HQ ATC. Lt Col Conner now serves as Recruiting Squadron Commander, Wright-Patterson AFB.**

# NAVIGATORS of the USSR

**Captain Donald W. RIGHTMYER**
**391 TFS/DO**
**Mt Home AFB, ID**

On the other side of the North Pole from the United States, the navigators wear a bland olive green uniform with distinctive sky-blue collar tabs. They are members of the Soviet Air Force, or *Voyenno Vozdushnyye Sily* (VVS). They are officers and flyers performing jobs like ours. Have you ever wondered about your Soviet counterparts—their lifestyles, professional flying activities and career patterns?

The prospective Soviet navigator's future begins to take shape at an early age with membership in the Little Octobrists (age 7 to 9) and later the Young Pioneers (age 10 to 15). Periodic meetings with these groups include sports contests, outdoor activities and riflery, as well as Marxist-Leninist ideology classes. Later, the fledgling navigators, (age 15 to 29) progress to the Komsomol (Young Communist League) where ideological sessions become more pointed and the activities become more paramilitary. Many Soviet youngsters also join the DOSAFF (Voluntary Society for Assistance to the Army, Air Force and Navy). This organization closely compares to our Civil Air Patrol. DOSAFF members may pursue aviation activities such as parachuting, glider and sport plane flying and navigation.

Each year, ads appear in Soviet newspapers seeking applicants for the two higher military aviation schools for navigators. Once final selections are made, the future navigator probably will be Russian (vs other ethnic groups) since entrance exams test written and oral Russian language and literature. Most likely the candidates will be young men. Soviet sources never mention women navigators, although it is possible there are some since the Soviet Air Force includes some female pilots.

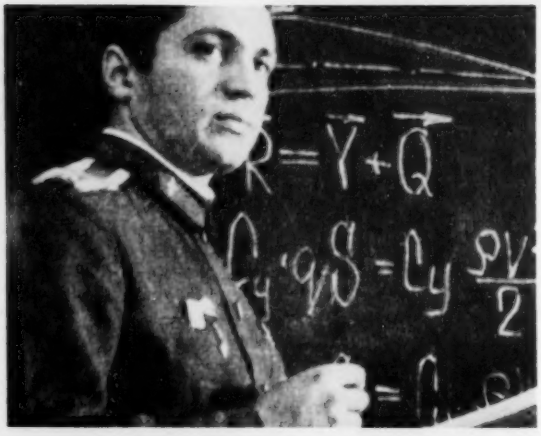
Navigator candidates report to either Voroshilovgrad, located southwest of Moscow in the Kiev military district, or the Chelyabinsk Higher Military Aviation School for Navigators situated just east of the Ural mountains. These schools are somewhat akin to our USAF Academy although not equal academically. The Soviet navigator does not graduate with the equivalent of a bachelor's degree.

During their four-year training course, student navigators pursue a variety of academic classes as well as flying training. Subjects studied include mathematics, electronics, meteorology, geometry, aircraft design and powerplants, history, military theory and Marxist-Leninist doctrine. Of course, countless hours are devoted to the discipline of *vozdushnaya navigatsiya* (air

navigation). Following one year of academics, cadets enter flying training. Training flights begin in the Li-2 transport aircraft which is specifically equipped for navigation training. Later, students progress to sorties in Il-28 Beagle and Tu-16 Badger. While these are older aircraft, they may be equipped with updated navigation and weapons delivery systems.

Before cadets graduate, they must successfully complete both flight and academic exams. Successful completion of the training program earns navigator wings and an engineering diploma with the rank of lieutenant in the Soviet military. Each year about 500 new lieutenants graduate to the ranks of air force and naval aviation navigators. Those who enter Soviet naval aviation service may receive an additional year of orientation before becoming fully qualified. New troops joining the Soviet navigator force also inherit a mandatory 25-year active duty commitment. By US standards, pay is poor but it is excellent compared to other Soviet professions such as lawyer, doctor and engineer. Many of the fringe benefits, such as priority for good housing, free travel, and elevated social status, make the navigator career very attractive.

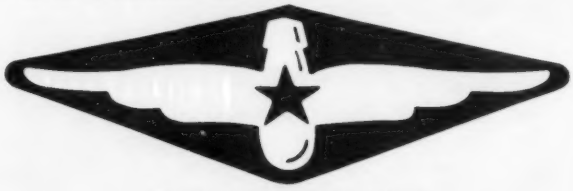





Following higher navigator school, new troops report to their units of assignment for operational qualification training in specific aircraft. Many missions require navigators. Soviet airlift aircraft, ranging from the An-12 Cub to the Il-76 Candid, feature navigator positions. Helicopters such as the Mi-6 Hook and Mi-12 Homer also employ navigators. Virtually all of the Soviet bomber force require navigators—the Mi-4 Bison, the Tu-16 Badger, the Tu-95 Bear and the Tu-22 Blinder. The Backfire and the new Blackjack bombers will certainly include navigators as crew members.

Air defense interceptors with multiplace cockpits, such as the Foxhound, the Fiddler, and the Firebar, may use navigators as weapon systems officers. The only ground attack aircraft known to employ a navigator-WSO is the Su-24 Fencer with its side-by-side seating cockpit.

Navigators are also found in airborne warning and control aircraft such as the older Tu-126 Moss and the newer Soviet AWACS, built on the Candid airframe, as well as the naval Il-38 May, in its antisubmarine role.



Navigator Instructor Wings

Soviet Air Force navigators can progress through various levels of command and staff during their careers. The senior ranking navigator, Lieutenant General of Aviation Vladimir Bulanov, holds the position of Chief Navigator in the Soviet Air Force. Other senior navigator positions include brigadier generals at the air army level, colonels and lieutenant colonels at the air regiment level and major and below at squadron or detachment level. Promotion is based upon handwritten, essay-type efficiency reports from superiors, as well as professional performance and loyalty to the Communist Party. Party membership is extremely important. If a young navigator is not invited to join the Party, when first eligible at age 27, he may expect to spend his entire career as a lieutenant.

After three years of flying service, Soviet navigators can apply for one of the higher study academies. They may select a Soviet Air Force academy or the Political Academy. These academies provide three additional years of higher military, engineering, and political education. While attending an academy, navigators report annually to a regular flying unit to maintain flying proficiency. Academy graduates are eligible for promotion to the higher echelons of command and staff or to political officer posts. A few navigators will attend the Air Engineering Academy which prepares them to serve as test navigators assigned to aircraft design centers.

Sniper Navigator Wings

Professional achievement is recognized with the award of such titles as Distinguished Military Navigator of the USSR. This honor is given for "distinguished mastery of aviation technology, and the training and education of flight cadres, coupled with many years of accident-free flying." Aside from such special awards, all navigators are recognized for their flying experience and accomplishments. With increased training, experience, and demonstrated ability, they progress from navigator third class to first class and possibly to instructor. A select few receive special designations, such as Military (Combat) Navigator, and, at the very pinnacle of readiness and experience, Sniper Navigator. All Soviet navigators proudly wear wings denoting their levels of experience.

While Soviet navigators enjoy a culture, ideology, and background radically different from ours, they share, with navigators around the world, service in our age-old profession of *navigatsiya*.

**Capt Rightmyer graduated from the USAF Academy in 1973 with a degree in History. After UNT and F-4 RTU, he flew F-4s in Korea, England and West Germany. He served with the Soviet Awareness Team in Washington, DC, before his present duty at Mt Home AFB.**

**First Lieutenant Mark C. D'ORIO**
**391 TFS/DO**
**Mt Home AFB, ID**

The crucial leg on any combat mission is the target run—that short, frenetic dash from the initial point to the target. Despite all else before, those final few miles usually determine success or failure. Often, success hinges on effective crew coordination, solid mission planning, and prior practice. That final leg compresses hours and hours of preparation, (by the aircrew, maintenance, intelligence, radar strike, weather and others), into a carefully orchestrated performance, where each motion is critical and time is always too short.

As the navigator of a fighter aircraft, fully half the burden for mission success or failure rests upon your shoulders. However, you cannot rely solely upon your navigator expertise. You function in that gray area of the "fightergator"—half navigator-bombardier, half fighter pilot. You must be aggressive and take charge.

What follows is a description of an IP-to-target run—that key part of the mission where the fightergator proves his worth. This scenario takes place in an F-111 at Saylor Creek Range, Idaho, but it could be any crew, any fighter, anywhere in the world.

Switches are thrown in perfect harmony as this symphony of combat begins. An F-111 screams toward its target on a night, low-level bombing mission. In the next three minutes, two men will bring to culmination thousands of hours of preparation by dozens of men and women—military and civilian. But now, in the darkness of the Idaho desert (or the blackness of the Soviet Urals), this symphony of force is played out by two helmeted warriors. Bathed in the eerie red light of their instrument panel, they alone will determine success or failure, hit or miss.



They have reached the initial point (IP), the point prior to the target. The IP is selected for its ease of recognition. Yet, it must also be small enough, precise enough, to offer a benchmark to the target.

"Left turn to 345," barks the right-seater—the Weapon Systems Officer. With a fine touch, the pilot sets the throttles for a predetermined groundspeed of 540 knots. Both crew members' eyes are riveted on the instruments through the turn, an especially dangerous time at night, close to the ground, with only the whirring computers assuring safe separation from the rocks 500 feet below and the enemy threat above.

"On heading, on groundspeed," calls the left seater as the Ardvark rolls wings level. "I've got the rocks." The call implies that the pilot is monitoring terrain clearance. Hundreds of rehearsals have told him that the terrain is now his concern. The right-seater hacks the clock for a back-up to the target and to confirm target information from the Inertial Navigation System (INS).

"Your steering is good," responds the WSO. INS heading and distance to the target agree with the planned heading and distance, carefully measured in the relaxed atmosphere of the squadron planning room.

"Roger," responds the pilot as he scans from terrain to engine instruments, compass, speedmeter, and terrain again. Satisfied that the silicon chips are all speaking the same language, he reengages the autopilot roll, once again turning control over to the computer avionics. Both crew members are "hands off." The amazing Ardvark is flying itself. The WSO's visor reflects the picture from the Attack Radar Scope (ARS)—a scene unlike any from the video game parlors. The radar confirms terrain clearance.

"I've got a ridge at five miles," speaks the right-seater.

"Rog, I've got it," echoes the pilot, confirming 10 thoughts in a simple utterance. Both crew members know that their present altitude will not clear the ridge 35 seconds in front of them. They also know from hours of pre-mission planning that this is normal. They are low in a valley with the Terrain Following Radar (TFR) hugging the earth.

"Ridge is at two miles," calls the WSO. "We should be climbing."

"Rog," echos the pilot.

Both crew members check their altimeters. The pilot scans the TFR scope, while the WSO checks the ARS.

"We've got a climb," says the left-seater, matter-of-factly. "The TFR shows us past the ridge."

"Roger," answers the WSO, confirming that the TFR and ARS radars agree.

Their calm and steady demeanor is not born of fearlessness. Rather, it is the product of task saturation. There is no room for doubt, only concentration. Words, like time, can't be wasted.

Less than two minutes to the simulated target, a 10-by-10 steel radar van.

"I'm arming up," says the WSO, as his hands dance across the weapons panel, giving life to the 24 500-lb bombs hanging from the Ardvark's wings.

"Switches are trail, bomb train pairs, nav delivery, both—mushrooms three, four, five and six depressed. Master arm is on. I've got a light in all four mushrooms."

The pilot listens carefully. Though each precise movement reflects hours of academic training, the whole scenario is played out in seconds.

"Sounds good," says the left-seater. An expert on the whole mission, he has processed the calls for switch settings and agrees that they are correct.

Ninety seconds to the target. A quick scan of engine instruments reveals all systems working as advertised. The maintenance troops, left behind two hours ago with a crisp salute, have done their jobs well.

The WSO again peers into the radar. Now the real fun begins. Selecting OFFSET on the F-111A's analog INS, he watches the crosshairs dance across the Attack Radar Scope. They finally rest beside an especially bright return, part of a familiar pattern.

"I've got the offset, pilot. Correcting right." The WSO moves the tracking handle to the right. The electronic crosshairs walk over the bright radar return. Again, hours of study and work by many translate into seconds of action by the crew.

Now satisfied that his rough offset aiming is good, the WSO selects TARGET on the INS. The crosshairs dance again. This time they fall almost exactly on a tiny blip on the ARS.

"I've got the target," the WSO informs the pilot. "Correcting right again."

"Coming right," responds the pilot. Now, near the target, the pilot hand flies the airplane following the WSO's directions, the computer's urgings, and his own experience.

"Less than a minute," calls the pilot, as he fine tunes the Ardvark's speed and heading. As always, he monitors terrain clearance, engine instruments, attitude, and groundspeed. Additionally, he checks the Radar Homing and Warning gear which advises of threats from enemy fighters, antiaircraft fire, and surface-to-air missiles.

This night, as the warriors streak across the dark Idaho desert, the threats are only simulated. But the crew trains to counter threats that will be real.

"Thirty seconds," warns the pilot. The WSO makes nearly imperceptible adjustments on the ARS, searching for the perfect crosshair placement.

"Fifteen seconds." The pilot checks the radar altimeter. "We're 500 feet—on the money." The WSO looks from the scope, calls out switch settings and confirms heading, altitude, groundspeed and terrain clearance.

"You've got a hot pickle button," advises the WSO. "Roger, I'm pickling," responds the pilot. His thumb depresses the red bomb-release button on his control stick.

The inertial system takes over now. With precision, the INS ripples the bombs from the airplane. Silently they fall, erupting the black Idaho desert into a spectacle of fire and noise. The radar camera later confirms a "shack." The mission is a success, thanks in large part to good crew coordination.

Inside the cockpit, new business replaces old as a safe escape and hasty exit become top priorities. There is little time for gloating now. That will come later, on the ground. And it will be rightfully deserved and shared by the many who acted through the few.

**In 1977, Lt D'Orio graduated from Keene State College with an English degree. After three years in the newspaper business, he was commissioned through OTS and completed UNT in 1981. Assigned to the F-111, Lt D'Orio serves at Mt Home AFB.**

# CARPS

**Major Thomas J. CORDELL**
**440 TAW/DOT (AFRES)**
**Gen Billy Mitchell Fld, WI**



Recent emphasis on aerial delivery training at unfamiliar locations has produced a universal problem for tactical airlift navigators—limited time to prepare. Slight delays—in obtaining weather data, flight-planning space, or even breakfast—can combine to reduce planning time. Since tactical training airdrops simulate actual wartime procedures, we need methods to plan quickly without sacrificing accuracy.

Using a computer is one of the most obvious ways to speed up mission planning and improve accuracy. If our objective is to develop training alternatives that apply in combat, however, the computer approach may have drawbacks. A reasonable alternative is to develop programs for the hand-held calculator which lends itself more to a tactical environment. The following CARP solution, written for the TI-59, is simple and easily adapted to other hand-held calculators or computers. Instructions accommodate the TI-59 with a printer, but the program works equally well with the calculator alone.

Step one of the CARP program is to store all required variables. Storage locations are numbered in conjunction with the MAC Form 512 for CARP Computations. Information required to complete a CARP computation is:

Item #1. Drop altitude.
#2. Terrain elevation.
#9. True altitude temperature.
#10. CAS (This program does not convert IAS to CAS).
#12. Rate of fall.
#15. Vertical distance.
#18. Time of fall constant.
#20. Ballistic wind direction.
#22. Wind direction. #41. Wind velocity.
#23. Magnetic course.
#27. Exit time.
#28. Deceleration quotient.
#36. Altimeter setting (no decimal point).
#37. Point of impact elevation.
#38. Usable DZ remaining (PI to TE).
#39. Safety zone distance.

After running the program, read the Forward Travel Distance. Recall item 21 and read the Drift Effect. Plot these factors to determine Stop Watch Distance. Enter Stop Watch Distance, #31, then press A. When the display stops, recall each storage location and enter the information on the Form 512. If desired, the command "1 INV 2nd LIST" will print a list of all memory locations.

The TI-59 searches for subroutines beginning at 000. Thus, a program will run slightly faster if subroutines are placed at the beginning. LBL A and LBL E are subroutines and therefore should be placed at the start.

000-000 Causes program execution to begin at LBL B, line 064. This is the start of the program.

001-016 This subroutine rounds to the nearest tenth. Most calculators, including the TI-59, have a built-in routine, FIX 1, that will do this rounding. Only the displayed information is rounded by this TI-59 method. Numbers placed in storage registers are not affected. Eventually, we read values directly from the storage registers; therefore, we need a subroutine.

017-062 Completes calculations after Stop Watch Distance is entered. Explanation follows at line 381.

063-064 Labels start of program.

065-072 Computes True Altitude.

073-087 Computes Pressure Altitude Variation

# ...on the TI-59

according to formula A on the CARP computation form.

088-095 Computes Pressure Altitude.

096-134 Computes Corrected Drop Altitude.

135-142 Loads register 07 with Terrain Elevation obtained from register 02 and computes Indicated Altitude.

143-245 Computes TAS from CAS.

245-250 Computes relationship between CAS and TAS. Stores the result in register 40.

251-257 Since the relationship of Rate of Fall to Adjusted Rate of Fall is identical to the relationship of CAS to TAS, adjusted Rate of Fall is figured by multiplying the Rate of Fall by the factor stored in register 40. Subroutine E rounds the result to nearest tenth.

258-265 Computes Altitude above Point of Impact.

266-271 Computes Stabilization Altitude.

272-278 Computes Time of Fall and rounds it to nearest tenth using subroutine E.

279-284 Computes Total Time of Fall.

285-298 Computes Drift Effect to nearest tenth.

299-318 Computes Drift Correction to nearest tenth.

319-324 Computes Magnetic Heading.

325-356 Computes Groundspeed to nearest tenth. (Register 51 is used as a temporary storage register for a factor needed in computing GS.)

357-364 Computes Forward Travel Time.

365-379 Computes Forward Travel Distance to nearest tenth.



**COMPUTED AIR RELEASE POINT COMPUTATIONS**

DATE: 15 MAR 84

NAVIGATOR'S NAME (Print): CAPT. MAXWELL DECKER | CALL SIGN: WERK 07 | ORGANIZATION: 440 TAW | NAVIGATOR'S SIGNATURE: Maxwell Decker

| | FACTORS | | STANDARD AND MODIFIED COMPUTATIONS | | |
|---|---|---|---|---|---|
| 1 | DROP ALTITUDE | | | STO 01 | |
| 2 | TERRAIN ELEVATION | + | | STO 02 | |
| 3 | TRUE ALTITUDE | | | | |
| 4 | PRESSURE ALTITUDE VARIATION | + A | | | |
| 5 | PRESSURE ALTITUDE | | | | |
| 6 | CORRECTED DROP ALTITUDE | B | | | |
| 7 | TERRAIN ELEVATION | + | | | |
| 8 | INDICATED ALTITUDE | | | | |
| 9 | TRUE ALTITUDE TEMPERATURE | | | STO 09 | |
| 10 | IAS / CAS / EAS | | | STO 10 | |
| 11 | TRUE AIRSPEED | | | | |
| 12 | RATE OF FALL | | | STO 12 | |
| 13 | ADJUSTED RATE OF FALL | C | | | |
| 14 | ALTITUDE ABOVE POINT OF IMPACT | D | | | |
| 15 | VERTICAL DISTANCE | — | | STO 15 | |
| 16 | STABILIZATION ALTITUDE | | | | |
| 17 | TIME OF FALL | E | | | |
| 18 | TIME OF FALL CONSTANT | + | | STO 18 | |
| 19 | TOTAL TIME OF FALL | | | | |
| 20 | BALLISTIC WIND | | | WV STO 20 | |
| 21 | DRIFT EFFECT | F | | | |
| 22 | DROP ALTITUDE WIND | | WD STO 22 | WV STO 21 | |
| 23 | MAGNETIC COURSE | | | STO 23 | |
| 24 | DRIFT CORRECTION | | | | |
| 25 | MAGNETIC HEADING | | | | |
| 26 | GROUND SPEED | | | | |
| 27 | EXIT TIME | | | STO 27 | |
| 28 | DECELERATION QUOTIENT | + | | STO 28 | |
| 29 | FORWARD TRAVEL TIME | | | | |
| 30 | FORWARD TRAVEL DISTANCE | G | | | |
| 31 | STOP WATCH DISTANCE | | | PUSH A | |
| 32 | STOP WATCH TIME | H | | | |
| 33 | USABLE DROP ZONE LENGTH | I | | | |
| 34 | USABLE DROP ZONE TIME | H | | | |
| 35 | RED LIGHT TIME (32 plus 34) | | | | |

| | | | |
|---|---|---|---|
| | PREFLIGHT ALTIMETER SETTING | | STO 30 |
| | DROP ZONE | | |
| | SCHEDULED DROP TIME(s) | | |
| | LOAD | | |
| | LOAD WEIGHT | | |
| | PARACHUTE (Type and number) | | |
| | FLIGHT STATION OF LOAD | | |

FORMULAS

A: 20.92 ( ) / ( ) 20.92 + —

B: Temperature / Pressure Altitude = Drop Altitude (Corrected Drop Altitude) — (ALTITUDE WINDOW)

C: Average Temperature / Average Pressure Altitude = (Adjusted Rate of Fall) Rate of Fall — (DENSITY ALTITUDE WINDOW)

D: True Altitude − Minus Point of Impact Elevation = (Altitude above Point of Impact) | STO 31

E: Adjusted Rate of Fall / Stabilization Altitude = 1.0 / (Time of Fall)

F: Total Time of Fall / 1.78 = (Drift Effect) Wind Speed

G: Groundspeed / 1.78 = (Forward Travel Distance) Forward Travel Time

H: Groundspeed / 1.78 = Distance (Time)

I: Usable DZ Remaining (PI to TE) | STO 38
Minus Safety Zone Distance | STO 39
Usable Drop Zone Length

RCRD DATA: SURFACE WIND; MEAN EFFECTIVE WIND; ALTITUDE WIND

DROP DATA: BALLISTIC WIND USED (M) (I); GROUND SPEED (C) (D) (S); DRIFT (C) (D) (S); GREEN LIGHT TIME (S) (V)

1. Store information in locations indicated.
2. Press RST then R/S.
3. When display stops, read Forward Travel Distance.
4. RCL 21 = Drift Effect.
5. Enter Stop Watch Distance then press A.
6. When display stops, press 1INV 2nd LIST.
7. Information numbered corresponding to CARP form.

MAC FORM 512 SEP 79 — REPLACES MAC FORM 512, DEC 77, WHICH IS OBSOLETE AND MAC FORM 353, JUN 76, WHICH MAY BE USED

*Figure 1*

TI-59 CARP program

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 000 | 12 | B | 064 | 12 | B | 128 | 85 | + | 192 | 08 | 8 | 256 | 42 | STO | 320 | 43 | RCL |
| 001 | 76 | LBL | 065 | 43 | RCL | 129 | 93 | . | 193 | 08 | 8 | 257 | 13 | 13 | 321 | 23 | 23 |
| 002 | 15 | E | 066 | 01 | 01 | 130 | 05 | 5 | 194 | 93 | . | 258 | 43 | RCL | 322 | 95 | = |
| 003 | 65 | × | 067 | 85 | + | 131 | 95 | = | 195 | 01 | 1 | 259 | 03 | 03 | 323 | 42 | STO |
| 004 | 01 | 1 | 068 | 43 | RCL | 132 | 59 | INT | 196 | 05 | 5 | 260 | 75 | - | 324 | 25 | 25 |
| 005 | 00 | 0 | 069 | 02 | 02 | 133 | 42 | STO | 197 | 54 | ) | 261 | 43 | RCL | 325 | 43 | RCL |
| 006 | 95 | = | 070 | 95 | = | 134 | 06 | 06 | 198 | 45 | Y^x | 262 | 37 | 37 | 326 | 24 | 24 |
| 007 | 85 | + | 071 | 42 | STO | 135 | 85 | + | 199 | 05 | 5 | 263 | 95 | = | 327 | 39 | COS |
| 008 | 93 | . | 072 | 03 | 03 | 136 | 43 | RCL | 200 | 93 | . | 264 | 42 | STO | 328 | 65 | × |
| 009 | 05 | 5 | 073 | 43 | RCL | 137 | 02 | 02 | 201 | 02 | 2 | 265 | 14 | 14 | 329 | 43 | RCL |
| 010 | 95 | = | 074 | 36 | 36 | 138 | 42 | STO | 202 | 05 | 5 | 266 | 75 | - | 330 | 11 | 11 |
| 011 | 59 | INT | 075 | 94 | +/- | 139 | 07 | 07 | 203 | 06 | 6 | 267 | 43 | RCL | 331 | 95 | = |
| 012 | 55 | ÷ | 076 | 85 | + | 140 | 95 | = | 204 | 03 | 3 | 268 | 15 | 15 | 332 | 42 | STO |
| 013 | 01 | 1 | 077 | 02 | 2 | 141 | 42 | STO | 205 | 54 | ) | 269 | 95 | = | 333 | 51 | 51 |
| 014 | 00 | 0 | 078 | 09 | 9 | 142 | 08 | 08 | 206 | 85 | + | 270 | 42 | STO | 334 | 43 | RCL |
| 015 | 95 | = | 079 | 09 | 9 | 143 | 43 | RCL | 207 | 01 | 1 | 271 | 16 | 16 | 335 | 22 | 22 |
| 016 | 92 | RTN | 080 | 02 | 2 | 144 | 10 | 10 | 208 | 54 | ) | 272 | 55 | ÷ | 336 | 75 | - |
| 017 | 76 | LBL | 081 | 95 | = | 145 | 55 | ÷ | 209 | 45 | Y^x | 273 | 43 | RCL | 337 | 43 | RCL |
| 018 | 11 | A | 082 | 65 | × | 146 | 01 | 1 | 210 | 93 | . | 274 | 13 | 13 | 338 | 23 | 23 |
| 019 | 42 | STO | 083 | 01 | 1 | 147 | 04 | 4 | 211 | 02 | 2 | 275 | 95 | = | 339 | 95 | = |
| 020 | 31 | 31 | 084 | 00 | 0 | 148 | 06 | 6 | 212 | 08 | 8 | 276 | 15 | E | 340 | 39 | COS |
| 021 | 65 | × | 085 | 95 | = | 149 | 01 | 1 | 213 | 06 | 6 | 277 | 42 | STO | 341 | 65 | × |
| 022 | 01 | 1 | 086 | 42 | STO | 150 | 54 | ) | 214 | 65 | × | 278 | 17 | 17 | 342 | 43 | RCL |
| 023 | 93 | . | 087 | 04 | 04 | 151 | 33 | X^2 | 215 | 05 | 5 | 279 | 85 | + | 343 | 41 | 41 |
| 024 | 07 | 7 | 088 | 43 | RCL | 152 | 85 | + | 216 | 75 | - | 280 | 43 | RCL | 344 | 95 | = |
| 025 | 08 | 8 | 089 | 03 | 03 | 153 | 01 | 1 | 217 | 05 | 5 | 281 | 18 | 18 | 345 | 94 | +/- |
| 026 | 95 | = | 090 | 85 | + | 154 | 54 | ) | 218 | 54 | ) | 282 | 95 | = | 346 | 85 | + |
| 027 | 55 | ÷ | 091 | 43 | RCL | 155 | 45 | Y^x | 219 | 34 | FX | 283 | 42 | STO | 347 | 43 | RCL |
| 028 | 43 | RCL | 092 | 04 | 04 | 156 | 03 | 3 | 220 | 65 | × | 284 | 19 | 19 | 348 | 51 | 51 |
| 029 | 26 | 26 | 093 | 95 | = | 157 | 93 | . | 221 | 03 | 3 | 285 | 43 | RCL | 349 | 95 | = |
| 030 | 95 | = | 094 | 42 | STO | 158 | 05 | 5 | 222 | 09 | 9 | 286 | 20 | 20 | 350 | 85 | + |
| 031 | 15 | E | 095 | 05 | 05 | 159 | 75 | - | 223 | 65 | × | 287 | 65 | × | 351 | 93 | . |
| 032 | 42 | STO | 096 | 55 | ÷ | 160 | 01 | 1 | 224 | 43 | RCL | 288 | 43 | RCL | 352 | 05 | 5 |
| 033 | 32 | 32 | 097 | 01 | 1 | 161 | 54 | ) | 225 | 09 | 09 | 289 | 19 | 19 | 353 | 95 | = |
| 034 | 43 | RCL | 098 | 00 | 0 | 162 | 55 | ÷ | 226 | 53 | ( | 290 | 55 | ÷ | 354 | 59 | INT |
| 035 | 38 | 38 | 099 | 00 | 0 | 163 | 53 | ( | 227 | 24 | CE | 291 | 01 | 1 | 355 | 42 | STO |
| 036 | 75 | - | 100 | 00 | 0 | 164 | 01 | 1 | 228 | 85 | + | 292 | 93 | . | 356 | 26 | 26 |
| 037 | 43 | RCL | 101 | 95 | = | 165 | 05 | 5 | 229 | 02 | 2 | 293 | 07 | 7 | 357 | 43 | RCL |
| 038 | 39 | 39 | 102 | 65 | × | 166 | 75 | - | 230 | 07 | 7 | 294 | 08 | 8 | 358 | 27 | 27 |
| 039 | 95 | = | 103 | 02 | 2 | 167 | 93 | . | 231 | 03 | 3 | 295 | 95 | = | 359 | 85 | + |
| 040 | 42 | STO | 104 | 95 | = | 168 | 00 | 0 | 232 | 93 | . | 296 | 15 | E | 360 | 43 | RCL |
| 041 | 33 | 33 | 105 | 94 | +/- | 169 | 00 | 0 | 233 | 01 | 1 | 297 | 42 | STO | 361 | 28 | 28 |
| 042 | 65 | × | 106 | 85 | + | 170 | 01 | 1 | 234 | 05 | 5 | 298 | 21 | 21 | 362 | 95 | = |
| 043 | 01 | 1 | 107 | 01 | 1 | 171 | 09 | 9 | 235 | 54 | ) | 299 | 43 | RCL | 363 | 42 | STO |
| 044 | 93 | . | 108 | 05 | 5 | 172 | 08 | 8 | 236 | 34 | FX | 300 | 22 | 22 | 364 | 29 | 29 |
| 045 | 07 | 7 | 109 | 95 | = | 173 | 01 | 1 | 237 | 85 | + | 301 | 75 | - | 365 | 43 | RCL |
| 046 | 08 | 8 | 110 | 94 | +/- | 174 | 65 | × | 238 | 93 | . | 302 | 43 | RCL | 366 | 26 | 26 |
| 047 | 95 | = | 111 | 85 | + | 175 | 43 | RCL | 239 | 05 | 5 | 303 | 23 | 23 | 367 | 65 | × |
| 048 | 55 | ÷ | 112 | 43 | RCL | 176 | 05 | 05 | 240 | 95 | = | 304 | 95 | = | 368 | 43 | RCL |
| 049 | 43 | RCL | 113 | 09 | 09 | 177 | 54 | ) | 241 | 59 | INT | 305 | 38 | SIN | 369 | 29 | 29 |
| 050 | 26 | 26 | 114 | 85 | + | 178 | 53 | ( | 242 | 95 | = | 306 | 65 | × | 370 | 95 | = |
| 051 | 95 | = | 115 | 03 | 3 | 179 | 24 | CE | 243 | 42 | STO | 307 | 43 | RCL | 371 | 55 | ÷ |
| 052 | 15 | E | 116 | 00 | 0 | 180 | 85 | + | 244 | 11 | 11 | 308 | 41 | 41 | 372 | 01 | 1 |
| 053 | 42 | STO | 117 | 00 | 0 | 181 | 02 | 2 | 245 | 55 | ÷ | 309 | 95 | = | 373 | 93 | . |
| 054 | 34 | 34 | 118 | 95 | = | 182 | 07 | 7 | 246 | 43 | RCL | 310 | 55 | ÷ | 374 | 07 | 7 |
| 055 | 85 | + | 119 | 35 | 1/X | 183 | 03 | 3 | 247 | 10 | 10 | 311 | 43 | RCL | 375 | 08 | 8 |
| 056 | 43 | RCL | 120 | 65 | × | 184 | 93 | . | 248 | 95 | = | 312 | 11 | 11 | 376 | 95 | = |
| 057 | 32 | 32 | 121 | 03 | 3 | 185 | 01 | 1 | 249 | 42 | STO | 313 | 95 | = | 377 | 15 | E |
| 058 | 95 | = | 122 | 00 | 0 | 186 | 05 | 5 | 250 | 40 | 40 | 314 | 22 | INV | 378 | 42 | STO |
| 059 | 15 | E | 123 | 00 | 0 | 187 | 54 | ) | 251 | 65 | × | 315 | 38 | SIN | 379 | 30 | 30 |
| 060 | 42 | STO | 124 | 65 | × | 188 | 53 | ( | 252 | 43 | RCL | 316 | 15 | E | 380 | 91 | R/S |
| 061 | 35 | 35 | 125 | 43 | RCL | 189 | 24 | CE | 253 | 12 | 12 | 317 | 42 | STO | 381 | 00 | 0 |
| 062 | 91 | R/S | 126 | 01 | 01 | 190 | 55 | ÷ | 254 | 95 | = | 318 | 24 | 24 | | | |
| 063 | 76 | LBL | 127 | 95 | = | 191 | 02 | 2 | 255 | 15 | E | 319 | 85 | + | | | |

380-381 Computations stop with Forward Travel Distance displayed. Recall 21 to read drift effect. Plot these two factors to determine Stop Watch Distance. Enter Stop Watch Distance and press A. Program jumps to LBL A and continues.

017-018 Labels location.

019-033 Stores Stop Watch Distance and then computes and stores Stop Watch Time.

034-041 Computes Usable Drop Zone Length.

042-054 Computes Usable Drop Zone Time.

055-061 Computes Red Light Time.

061-061 Computations stop with Red Light Time displayed.

Use RCL xx to read storage registers corresponding to the numbered lines on the MAC Form 512. If a printer is available, the instruction "1 INV 2nd LIST" will print a listing of all memory locations.

Figure 1 is an overprinted copy of the MAC Form 512. Information required to execute the program is annotated by STO xx. Abbreviated instructions are included in the lower righthand corner. Good luck with this computer CARP program. I welcome your feedback. May all of your airdrop scores be PIs.

**An aviation cadet graduate in 1961, Maj Cordell completed UNT and NBT. He then served at Kirtland AFB and Guam before leaving active duty in 1966. He next worked as a commercial navigator, flight officer, and copilot. Maj Cordell has served in the Reserves since 1974.**

# Indian Ocean Enigma

**Captain Jimmy R. ALLEN**
**323 FTW/DOVN**
**Mather AFB, CA**

It was the evening of 9 February 1980. Lieutenant Al T. Tude, the world's second greatest navigator, with his crew and passengers, had just departed Diego Garcia, via a great circle course, direct to Johannesburg, South Africa. Under the cover of darkness, Al and the crew were ferrying a team of Navy Seals to Johannesburg to rescue the Hope Diamond which was stolen by a band of local rebels.

Mission preflight had been uneventful, except when one of the Seals crushed a can of hydraulic fluid on his buddy's noggin. With the mess resolved, Al's aircraft, a camouflaged C-130, slipped effortlessly into the night air. Soon, Al was settled into his rigid overwater fixing routine—every hour and twenty minutes whether needed or not. Things were going smoothly until the flight encountered a squall line a few hours from departure.

"No sweat," exclaimed Al, remembering all those handy airplot procedures learned in navigation school. But alas, luck had abandoned our dauntless friend. During one of many heading alters, both compass systems failed. Resorting to the trusty standby compass, Al was alarmed to find a rubber chicken dangling from where the whisky compass should have been.

As the crew forged on, the weather worsened. Finally, the icing accumulation became too great. Crew and passengers quickly prepared to ditch. The Seals would finally be in their own element.

As the storm passed the next morning, the flyers and Seals were peacefully adrift somewhere in the 28,350,000 square miles of the Indian Ocean. Before exiting the aircraft, Al managed to salvage his charts, sextant, Air Almanac, H.O. 249s, and DR Kit. On that first day, he took three observations of the sun as it crossed from his left to right. The observations, at 0800Z, 0810Z, and 0820Z, produced Hos of 86-12, 88-08, and 87-57 respectively. Based upon these observations, where were Al and his buddies (coordinates) and in what direction (true course) did they paddle to reach the nearest bona fide island?

After determining their position, Al convinced the Seals (he promised them 20 copies of The Sands of Iwo Jima) to push the raft toward the island. They immediately jumped overboard and began kicking furiously. The Seals churned the water until the hapless group finally ran aground. With a few "minor" deviations, they had been holding the initial course Al computed. (The Seals were playing tag with sharks.) Once on the island, Al set out to determine his new location. At 0630Z he observed the sun's Ho of 60-09. As he was deciding how to use the single LOP, a second body suddenly became visible midway up in the northwestern sky. He quickly took an observation at 0700Z. The Ho was 37-27. Being a celestial wizard, Al concluded which body he shot and resolved both LOPs to a position.

What was that second body that Al shot? Where did he and his shipwrecked buddies spend George Washington's birthday? (Name the island.)

*Look for the "school solution" in the summer issue of THE NAVIGATOR.*

**A graduate of the University of Missouri, Columbia, Capt Allen completed UNT in 1976. He was then assigned to Dyess AFB in the C-130/H. Capt Allen has served at Mather AFB since 1980 and is presently assigned to Stan/Eval.**

# THE NEW ELECTRONIC SEXTANT

**Captain Robert R. ALLMON**
**924 AREFS**
**Castle AFB, CA**

1808Z "Boom, Nav. We'll be shooting in about one minute."
1809 "OK, Boom, start the shot."
1812½ "Boom, isn't that shot over yet?"
"Don't trust this one, Nav. The indices won't realign."
1813 "What was that ERLS rule they taught us in training?"

Does the preceding dialogue sound familiar? This could have been you if you had a boomer or EWO shooting for you. Perhaps, on this occasion, you would have consumed additional time by shooting again yourself. Well, you'll be relieved to know that the old D1 sextant will soon be retrofitted with a new electronic averager. This is the first major modification to equipment manufactured in the 1940s and 50s. Modifications will be accomplished at each Air Force base.



How does the new averager compare with the old? The mechanical averager contains more than 300 interlocking parts, separately manufactured over 30 years ago. The averager mechanism couples to an internal gear train and then to the sextant altitude counter. As a star or planet is observed and the altitude knob rotated, changes in altitude are transmitted to the averager mechanism. A Deimel-Black disk-and-ball integrator averages altitude shaft motion and moves the sextant indices. After a two-minute observation, the two indices are realigned and the average altitude noted. Included in the mechanical averager unit are a two-minute clock and a spring mechanism to close the shutter. A maintenance overhaul of the averager can take two to three days. Does this sound like outdated technology? The Air Force thinks so and sees a need to upgrade it. The modified sextant will feature a new electronic digital averager.

The heart of the new averager is an LSI microcomputer. The computer processor has calculating power, as well as the ability to control the two-minute clock, shutter, and indices. Mechanical sextant operation, except for the actual averager function, is similar to sextants currently used. One main equipment difference is the use of an input plug and corresponding twin-lead power cable (Y-cord) to mate the equipment with current aircraft power systems. In addition to the standard power lead for sextant illumination, the second lead plugs into the back of the averager mechanism to power it. A second variation between the old and new sextants is conversion from mechanical to electronic digital indices. Also, on the modified unit the old start and rewind levers will be replaced by large, easily accessible push buttons (Fig 1).

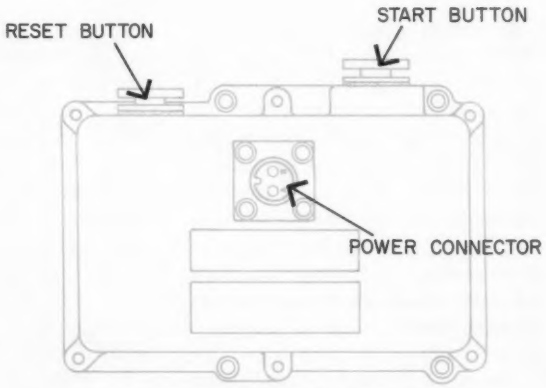



*Figure 1*

The electronic sextant averager's microcomputer computes altitude averages. During celestial observations, an optical shaft converts sextant altitude motion to digital impulses. The microcomputer counts these pulses, as the shaft rotates, and stores the data. As a celestial body is observed, the computer samples its memory periodically and generates a sum from the sampled data. At the end of the observation

an average is obtained from the sum of samples taken.

The microcomputer next generates instructions which permit the operator to accurately determine the average altitude. The two-minute clock and indices are observed through a small window (Fig 2). Window displays consist of two digits, a Timer Running Indicator, an Exact Average Indicator and a red and yellow light-emitting diode (LED), arranged above and below the digital display, respectively. With the new averager, sextant operation is simplified.

After depressing the reset button, the upper red LED and bottom yellow LED are off and the digital display reads 00 (Fig 2). These two digits serve as the half-time readout (clock). The elapsed clock time may be added directly to the starting time of the observation to compute the mean time of the observation. One outstanding advantage of the digital clock system is that no zero run-down delay occurs when the timer is reset. Have the indices ever failed to realign after your shot? With the modified sextant, this problem is eliminated. Resetting the timer also opens the solenoid-activated shutter.

When the start/stop switch is depressed and released, the Timer Running indicator (illuminated bar) begins flashing and the clock display starts counting (Fig 2). The microcomputer begins reading shaft information and incrementing the display every two seconds. As with the unmodified unit, the shot must be run for at least 30 seconds—a reading of 15 on the half-time display—before it can be stopped. After 30 seconds, the shot can be stopped any time by again depressing and releasing the start/stop button. The shutter closes when the timer is stopped. If not stopped, the timing averager runs for two minutes.

To obtain the average altitude reading, the altitude control knob must be rotated as with the old averager. As the knob is rotated, either the red or yellow LED will flash at a rate proportional to the distance the average value is from the final altitude counter reading. A flash rate of 15 Hz indicates an average of more than five degrees (greater than one revolution of the altitude control knob). The appropriate LED will flash to indicate the direction the altitude knob must be rotated to find the average. A flashing red LED indicates the final altitude is higher than the computed average. The yellow LED flashes to indicate that the final altitude is lower than the computed average. When the altitude counter is rotated to within 2.5° to 5.0° of the average, the flash rate slows to 8 Hz. When the value is within 2.5° of the average, the flash rate slows to 5 Hz. As the altitude readout reaches a value within plus or minus 1.5 arc minutes of the average, both LEDs illuminate. Within plus or minus 0.5 arc minutes, the LEDs and the Exact Average Indicator illuminate together. If the altitude knob is turned past the average, then the opposite LED will so indicate by flashing at the 5 Hz rate.

The microcomputer holds the average value until either the rewind lever is depressed (reset) or the start/stop switch is again depressed and the observation continued. At the conclusion of an observation, the average value must be recorded within five minutes or it will automatically clear, leaving no indications in the clock window. To clear the window sooner, simply depress the reset button.



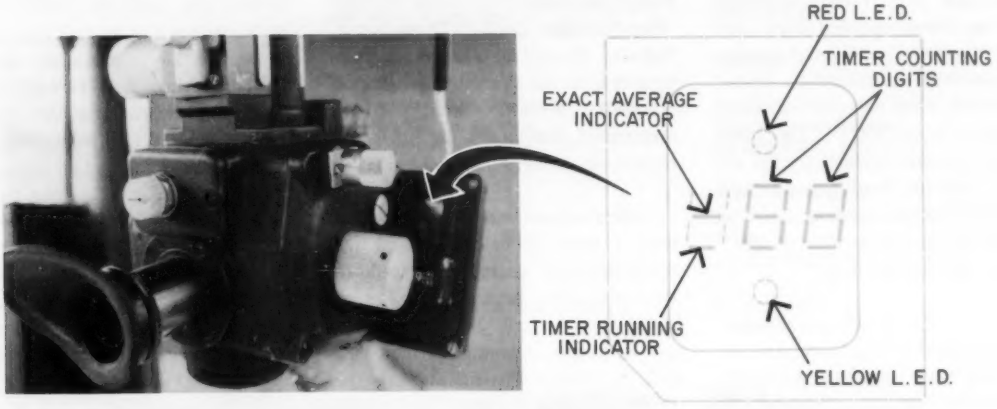



*Figure 2*

With the modified sextant, equipment maintenance promises to be greatly enhanced. A 40-pin zero insertion force socket holds the microcomputer in place. This installation protects the microcomputer and prevents wear to printed circuit boards. Basically, the electronic averaging mechanism has drastically fewer moving parts than the present mechanical version. Troubleshooting the averager requires only an oscilloscope and a VOM meter.

The new electronic averaging system is highly reliable. The mean time before failure for the averager power assembly is 33,696 hours and 105,898 hours for the main assembly itself. Student navigators will see the new equipment soon. Mather AFB should begin installing the electronic averagers this spring. As you can see, the operational navigator force will benefit from a high-technology retrofit to a very basic and venerable navigation tool.

**In 1972, Capt Allmon graduated from California State University, Sacramento, with a degree in Economics. After UNT, he was assigned to Ubon AB in the AC-130. Next came duty in the KC-135 at Grand Forks AFB followed by service at Kadena AB. In 1979, he was reassigned to Mather AFB. Capt Allmon now serves at Castle AFB in the KC-135.**

# Professional Reading



**Captain Donald W. RIGHTMYER**
**391 TFS/DO**
**Mt Home AFB, ID**

The air war in Southeast Asia was a study in contrast. World War II-vintage A-1 Skyraiders attacked an unseen foe beneath heavy jungle canopies while F-4 and F-105 jets penetrated the most heavily defended spot on earth,—the airspace over Hanoi-Haiphong. American airmen operated under some of the most strenuous rules of engagement ever experienced while the air munitions tonnage dropped was three times that of World War II. The evolution of air weapons technology saw the air battle over the North begin without defensive electronic countermeasures and end with the employment of precision laser-guided weapons.

Three recently published books deal with specifics of the Southeast Asia air war. Each was written by an active duty Air Force officer during his tour with the Office of Air Force History in Washington, D.C. The books are *Search and Rescue in Southeast Asia*, by Earl H. Tilford, Jr.; *Operation Ranch Hand: The Air Force and Herbicides in Southeast Asia, 1961-1971*, by William A. Buckingham, Jr. and *Development and Employment of Fixed-Wing Gunships, 1962-1972*, by Jack S. Ballard. Each of these books covers an area of U.S. Air Force involvement in Vietnam which, though little understood, was vital to the conduct of overall air and ground operations.

Tilford's *Search and Rescue* begins with a brief historical look at the development of search and rescue of downed aviators, particularly in Europe during World War II, the Korean War, and up to the beginning of increased U.S. presence in Vietnam in 1960. The almost total lack of a search and rescue (SAR) system during the early years of Vietnam forced reliance on Air America assets and other regional forces. As the years and American force presence accumulated, SAR resources and capabilities grew to keep pace with the tempo of air operations. Tilford also describes many specific rescue sorties into North Vietnam, such as the Son Tay mission and the post-Vietnam Mayaguez rescue efforts. *Search and Rescue* provides excellent insight into the rich heritage of SAR during the last quarter century.

*Operation Ranch Hand* introduces its review of defoliation operations in Vietnam with a brief historical survey of aerial spraying efforts since their advent. Author Buckingham then provides a comprehensive history of herbicides used in Vietnam and aptly describes the technical side of actual spraying missions. He also stresses

appreciation for both the strategic and political issues considered by leaders, from the U.S. President on down the chain of command.

Of the selections I mentioned at the outset, Ballard's book probably will elicit the most memories among Air Force navigators. Gunships really had their birth in Southeast Asia. They continue to be a viable conventional warfare weapon today. Ballard's gunship volume traces the evolution of the gunship concept, and resultant hardware, through the AC-47, AC-119, and AC-130. Throughout the entire SEA war, gunships played a vital role in village defense, convoy escort, truck-killing campaigns along the Ho Chi Minh Trail, and Commando Hunt operations. Mr. Ballard's account may be the definitive work on the Vietnam chapter of gunship history.

Each of these books is available from the Government Printing Office in Washington, D.C. or your base library. Plan to include one of them in your near-term professional reading plans.

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# NAVIGATOR TRAINING- AN EVOLUTIONARY PROCESS

**Major David J. JIRELE**
**323 FTW/DOTCU**
**Mather AFB, CA**

For many Undergraduate Navigator Training (UNT) graduates who trained at Mather AFB, memories of their training programs have probably faded in direct proportion to time elapsed since graduation. If you have been away from Mather for any length of time, your recollection of UNT training may differ drastically when compared with today's training regimen. This is because the UNT syllabus is constantly evolving.

My curriculum manager's job in the 323d Flying Training Wing's Training Division is directly related to syllabus evolution. Curriculum revision is never finished. As soon as one change is implemented, the next is already on the drawing board. In this article, I'll discuss navigator training under the restructured syllabus, effective with FY 84 classes, as well as pending changes to the Navy training program.

First, some background on how and why we change the curriculum. An often-heard expression from those who struggle with syllabus changes is, "Why reinvent the wheel? Wait two years and we'll be doing things the old way again." At times, that statement has an element of truth but those of us charged with curriculum management believe that change can improve the quality of training. Curriculum change produces navigators more capable of doing the job, no matter what the assignment or command.

Commands using navigators—SAC, TAC, and MAC—ultimately provide the impetus for syllabus change. A formal agreement, between ATC and these major commands, specifies navigator training standards. This document, called the Course Training Standard (CTS), is the foundation for curriculum development. The training syllabus simply expands the CTS into a comprehensive list of objectives which, when attained, will produce UNT graduates who meet command standards. The using commands periodically review and update the CTS. To keep the syllabus in compliance with user needs, the Training Division Curriculum Branch works full time.

Not all syllabus changes are generated by the CTS. Some are dictated by ATC, others are by-products of local program review. The most recent curriculum change restructured the UNT program flow. Beginning with FY 84 UNT classes, all T-37 flight training missions are flown at the start of the program. Some of you may recall having received your initial flight training under a similar arrangement—so what's new? I'll not chronicle every change made in the last ten years, but a short review of major curriculum changes may lend a better perspective.

Since late 1974, undergraduate navigator flight training has been conducted in the T-43A aircraft and the T45 simulator. In September 1974, the T-37 joined Mather's training fleet to introduce students to flight in a high performance jet. Many new navigators graduate to similar fighter aircraft. Gone was the venerable T-29. The all-jet training process began with three initial flights in the T-37. From there, students advanced to the T-43 and T45 simulator. The first all-jet class, 76-03, entered training on 2 January 1975. Later syllabus changes added four T-37 flights at the end of training, during the Low Level phase. The training program remained roughly this way until recently.

With today's syllabus, entering students complete six training flights in the T-37, including a check, before advancing to the T-43. This major departure from the old flight training flow improves training quality in several ways. First, students receive increased exposure to the flight environment before moving to the T-43. Second, students are less confused—they do not have to study and use two different aircraft systems and procedures simultaneously. A third benefit relates to the assignment process. With today's program, students are better prepared to decide assignment preferences. Those unable to adapt to a high performance fighter aircraft are identified much earlier in the program. Finally, the recent syllabus revision helped to streamline the UNT program. One T-37 sortie was eliminated from UNT and added to the graduate Tactical Navigation syllabus.

The new UNT syllabus flow (Fig 1) illustrates the standard building block process common to every Mather curriculum. Course names may

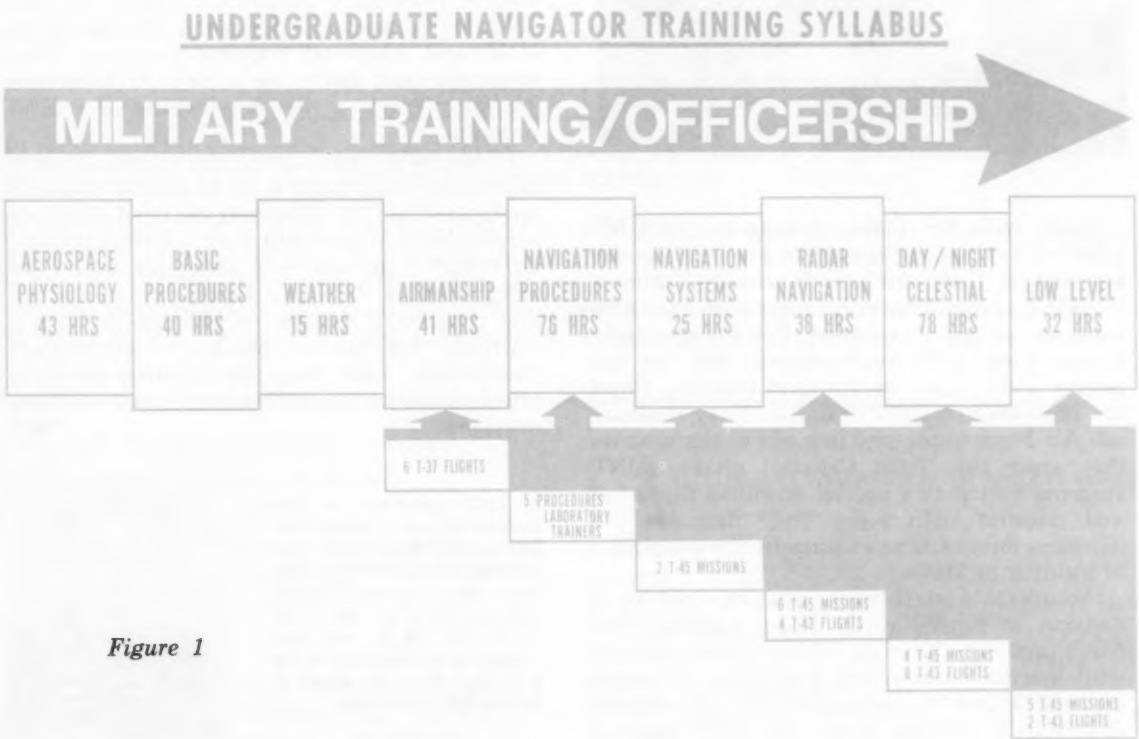
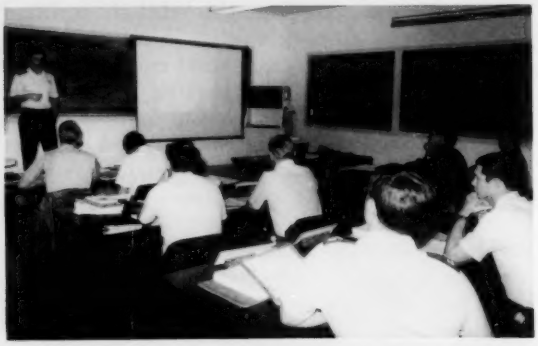



*Figure 1*

change, but overall program content changes little. The academic classroom still provides the cornerstone for every training phase. Students now receive about 130 hours of academics before their first T-37 ride.



Along with the major change to the UNT syllabus, curriculum managers are revising the Interservice Undergraduate Navigator Training (IUNT) program. Presently, Navy students enter training in the Navigation Procedures block. Unlike their UNT counterparts, they do not receive T-37 flights or low-level training. From the beginning of IUNT training, Navy students use Air Force forms and procedures. As soon as they enter the Night Celestial phase, IUNT students switch to a special maritime flight log and celestial sight form. They then use the maritime forms and procedures for the remainder of training at Mather.

Considerable staff work was involved in a decision to further revise Navy training. The Navy prefers to have its students train entirely with maritime forms and procedures. A major concern is how to accomplish the task without adversely impacting upon the UNT mission.

Final details have been resolved and the revised Navy training program is scheduled to begin this November. The new program will employ Navy training forms from the very beginning.

Conducting a specialized Navy program with an already large UNT mission will require increased flexibility on everyone's part. Growing pains and inevitable gliches are bound to occur. However, with the professionalism, spirit and dedication of Mather's instructors, we will succeed.

As I stated earlier, any new syllabus change always seems to be followed by another. The last Course Training Standard conference, in June 1982, laid groundwork for many changes to the UNT and advanced training programs. More emphasis will likely be drawn to Electronic Warfare Training by lengthening the EWT program.

Tomorrow's navigator may be trained differently from today's as changing missions impact on the CTS. Whatever the need, Mather's curriculum managers will work to ensure that the UNT/IUNT courses meet specifications of the using agencies. As with a finely tuned racing car, that constantly requires adjustments to keep it running smoothly, Mather's curriculum "mechanics" must keep the syllabus precisely tuned to ensure top performance in our military missions.

**A 1971 graduate of the University of Minnesota, Minneapolis, Capt Jirele was commissioned via OTS in 1972. After UNT, he was initially assigned to Ubon AB in the F-4D. In 1974, he was reassigned to Travis AFB in the C-5. Capt Jirele has served at Mather AFB since 1980.**

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